



WHAT IS CLAIMED IS:

1. A magnetic random access memory comprising:
  - a memory cell having a first magnetic layer to record data;
  - 5 a write line including a function which applies a magnetic field to the first magnetic layer; and a second magnetic layer which covers all or part of the write line,
  - 10 wherein the first magnetic layer is exchange-coupled to the second magnetic layer, and a sum of a first magnetic volume  $Ms_1 \times t_1$  of the first magnetic layer and a second magnetic volume  $Ms_2 \times t_2$  of a first portion of the second magnetic layer that is exchange-coupled to the first magnetic layer is smaller than a third magnetic volume  $Ms' \times t'$  of a second portion of the second magnetic layer except the first portion (where  $Ms_1$  is saturation magnetization of the first magnetic layer,  $t_1$  is a thickness of the first magnetic layer,  $Ms_2$  is saturation magnetization of the first portion of the second magnetic layer,  $t_2$  is a thickness of the first portion of the second magnetic layer,  $Ms'$  is saturation magnetization of the second portion of the second magnetic layer, and  $t'$  is a thickness of the second portion of the second magnetic layer).
  - 15
  - 20
  - 25 2. The memory according to claim 1, wherein a quotient of dividing the sum of the first and second magnetic volumes by the third magnetic volume is not

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DISCLOSURE  
PURPOSES ONLY

Related Pending Application  
Related Case Serial No: 10/379,915  
Related Case Filing Date: 03-06-03

more than 0.9.

3. The memory according to claim 1, wherein  
a quotient of dividing the sum of the first and second  
magnetic volumes by the third magnetic volume is not  
5 more than 0.3.

4. The memory according to claim 1, wherein  
magnetization of the second magnetic layer is oriented  
in a direction of length of the write line.

5. The memory according to claim 4, wherein  
10 magnetization of the first magnetic layer is oriented  
in a direction of width of the write line.

6. The memory according to claim 5, wherein  
a write current having a direction depending on a write  
data value flows through the write line.

15 7. The memory according to claim 4, wherein  
magnetization of the first magnetic layer is oriented  
in the direction of length of the write line.

8. The memory according to claim 7, wherein  
a write current having always one direction flows  
20 through the write line.

9. The memory according to claim 1, wherein  
the second magnetic layer is higher in magnetic  
permeability than the first magnetic layer.

10. The memory according to claim 1, wherein the  
25 second magnetic layer is higher in saturation flux  
density than the first magnetic layer.

11. A magnetic random access memory comprising:

a memory cell having a first magnetic layer to record data;

a write line including a function which applies a magnetic field to the first magnetic layer; and

5 a second magnetic layer which covers all or part of the write line,

wherein the first magnetic layer is exchange-coupled to the second magnetic layer, and a thickness of a first portion of the second magnetic layer that is 10 exchange-coupled to the first magnetic layer is set smaller than a thickness of a second portion of the second magnetic layer except the first portion.

12. The memory according to claim 11, wherein the write line is connected to a write selector transistor 15 to select the memory cell in write mode.

13. The memory according to claim 11, wherein a nonmagnetic layer is interposed between the first and second magnetic layers.

14. The memory according to claim 13, wherein the 20 nonmagnetic layer is formed from Ru.

15. The memory according to claim 11, wherein the first magnetic layer is arranged above the write line.

16. The memory according to claim 15, wherein the 25 second magnetic layer covers at least a side or lower surface of the write line.

17. The memory according to claim 11, wherein the second magnetic layer is arranged only near the memory

cell.

18. The memory according to claim 11, wherein  
a layered structure of the first portion of the second  
magnetic layer is the same as a layered structure of  
the second portion of the second magnetic layer.  
5

19. The memory according to claim 11, wherein  
a material which forms the first portion of the second  
magnetic layer is the same as a material which forms  
the second portion of the second magnetic layer.  
10

20. The memory according to claim 11, wherein the  
first magnetic layer is heated by a write current  
flowing through the write line in write mode.  
15

21. The memory according to claim 11, wherein  
magnetization of the second magnetic layer is oriented  
in a direction of length of the write line.  
25

22. The memory according to claim 21, wherein  
magnetization of the first magnetic layer is oriented  
in a direction of width of the write line.  
20

23. The memory according to claim 22, wherein  
a write current having a direction depending on a write  
data value flows through the write line.  
25

24. The memory according to claim 21, wherein  
magnetization of the first magnetic layer is oriented  
in the direction of length of the write line.  
25

25. The memory according to claim 24, wherein  
a write current having always one direction flows  
through the write line.

26. The memory according to claim 11, wherein the second magnetic layer is higher in magnetic permeability than the first magnetic layer.

5 27. The memory according to claim 11, wherein the second magnetic layer is higher in saturation flux density than the first magnetic layer.

28. The memory according to claim 11, wherein the first magnetic layer is exchange-coupled to the second magnetic layer on lower and side surfaces.

10 29. A magnetic random access memory comprising:

a memory cell having a first magnetic layer to record data;

a write line including a function which applies a magnetic field to the first magnetic layer; and

15 a second magnetic layer which covers all or part of the write line,

wherein the second magnetic layer has a recess from which an upper surface of the write line is exposed, the memory cell is arranged in the recess, and the first magnetic layer is exchange-coupled to the second magnetic layer on a side surface.

20 30. The memory according to claim 29, wherein the write line is connected to a write selector transistor to select the memory cell in write mode.

25 31. The memory according to claim 29, wherein a nonmagnetic layer is interposed between the first and second magnetic layers.

32. The memory according to claim 31, wherein the nonmagnetic layer is formed from Ru.

33. The memory according to claim 29, wherein the first magnetic layer is arranged above the write line.

5       34. The memory according to claim 33, wherein the second magnetic layer covers at least a side or lower surface of the write line.

10      35. The memory according to claim 29, wherein the second magnetic layer is arranged only near the memory cell.

36. The memory according to claim 29, wherein the first magnetic layer is heated by a write current flowing through the write line in write mode.

15      37. The memory according to claim 29, wherein magnetization of the second magnetic layer is oriented in a direction of length of the write line.

38. The memory according to claim 37, wherein magnetization of the first magnetic layer is oriented in a direction of width of the write line.

20      39. The memory according to claim 38, wherein a write current having a direction depending on a write data value flows through the write line.

25      40. The memory according to claim 37, wherein magnetization of the first magnetic layer is oriented in the direction of length of the write line.

41. The memory according to claim 40, wherein a write current having always one direction flows

through the write line.

42. The memory according to claim 29, wherein the second magnetic layer is higher in magnetic permeability than the first magnetic layer.

5 43. The memory according to claim 29, wherein the second magnetic layer is higher in saturation flux density than the first magnetic layer.

10 44. The memory according to claim 29, wherein the first magnetic layer is exchange-coupled to the second magnetic layer on lower and side surfaces.

ABSTRACT OF THE DISCLOSURE

A write line is covered with a yoke material. The recording layer of an MTJ element is exchange-coupled to the yoke material. The total magnetic volume  $\sum M_{si} \times t_i$  of the recording layer of the MTJ element and a portion of the yoke material that is exchange-coupled to the recording layer is smaller than the magnetic volume  $\sum M_{si'} \times t_i'$  of the remaining portion 5 of the yoke material that covers the write line.

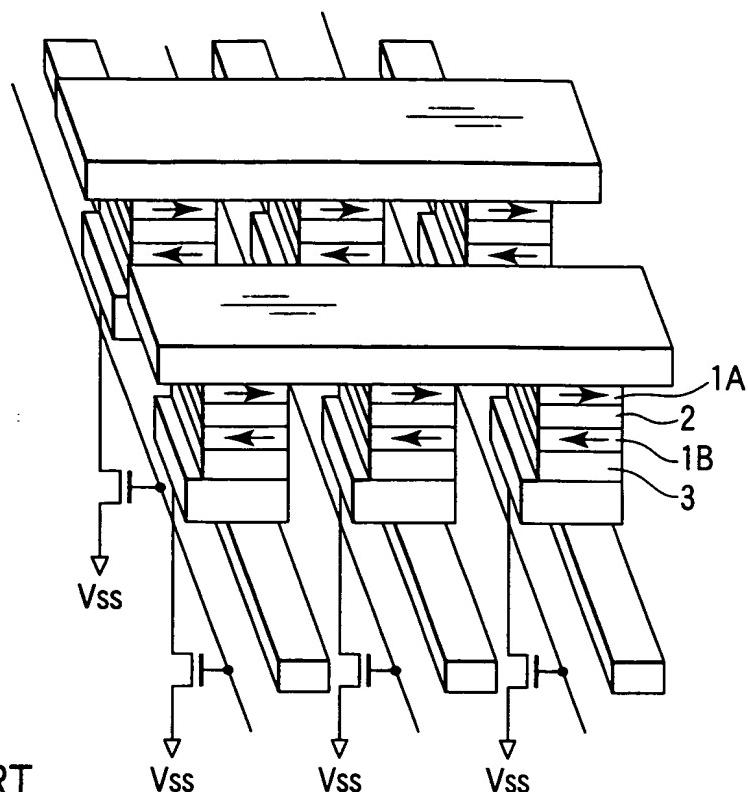
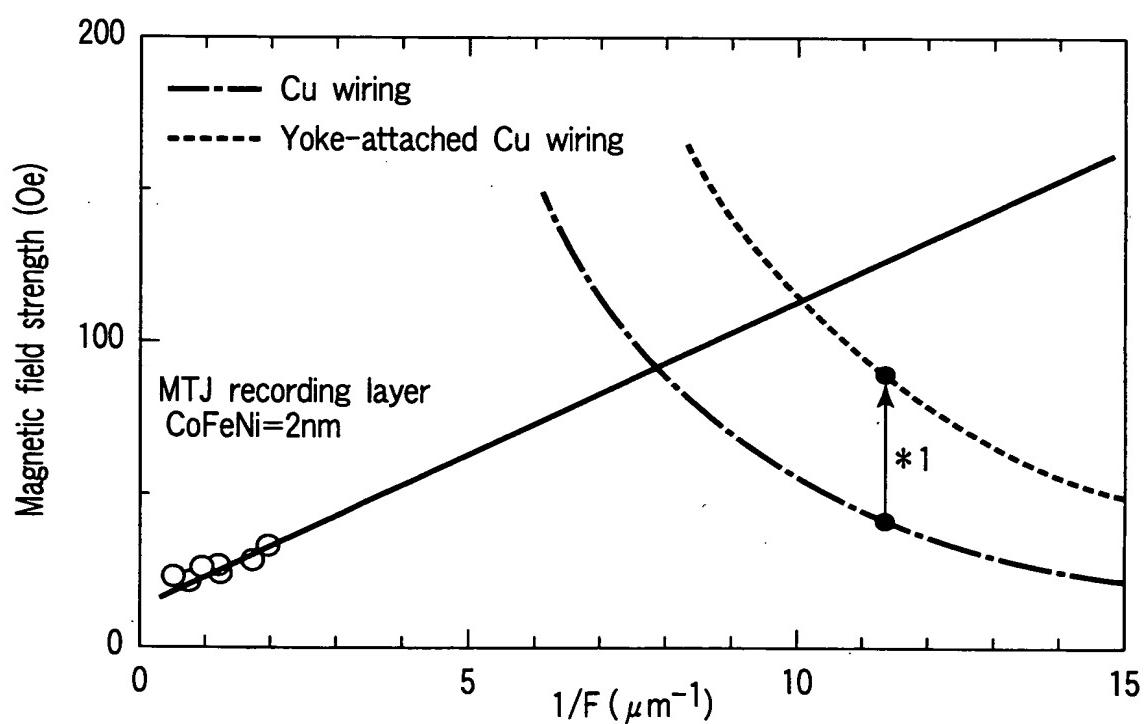


FIG. 1  
PRIOR ART



\*1: Magnetic field strength is almost double  
(Current for generating same magnetic field is 1/2)

FIG. 4 PRIOR ART

FIG. 2  
PRIOR ART

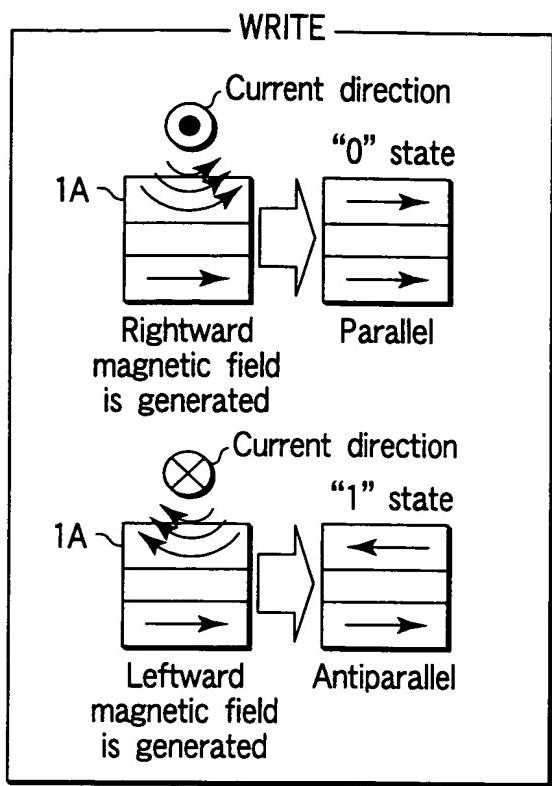
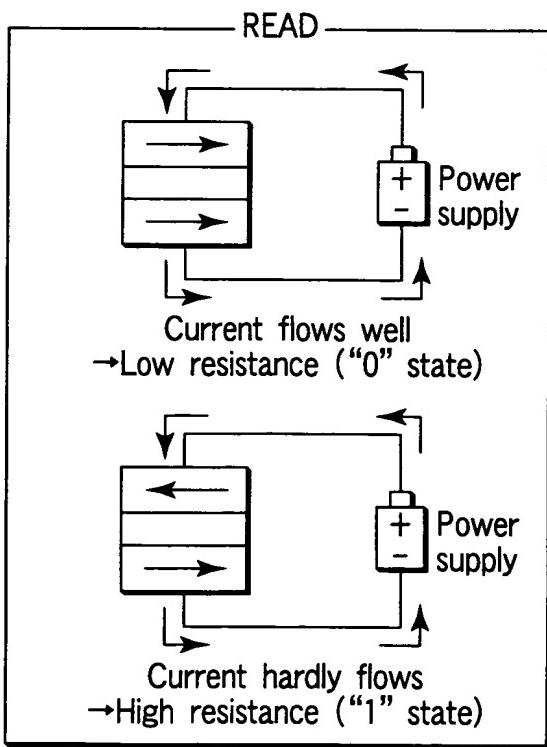
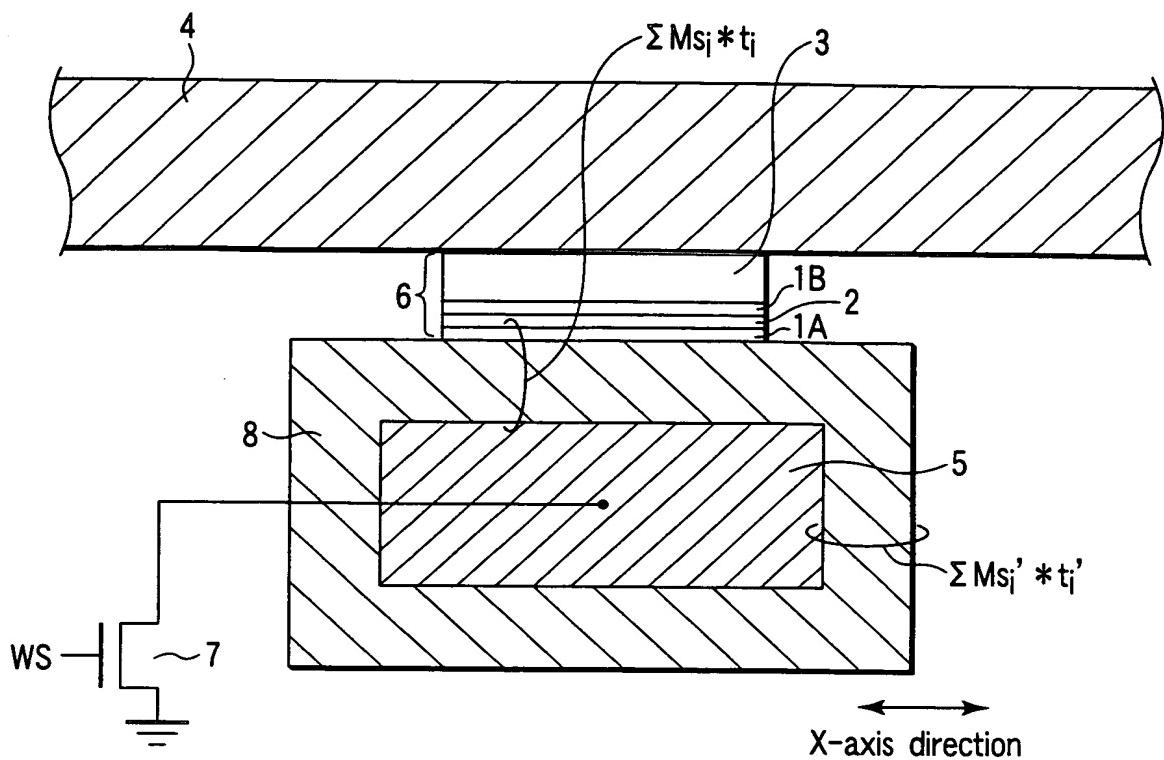
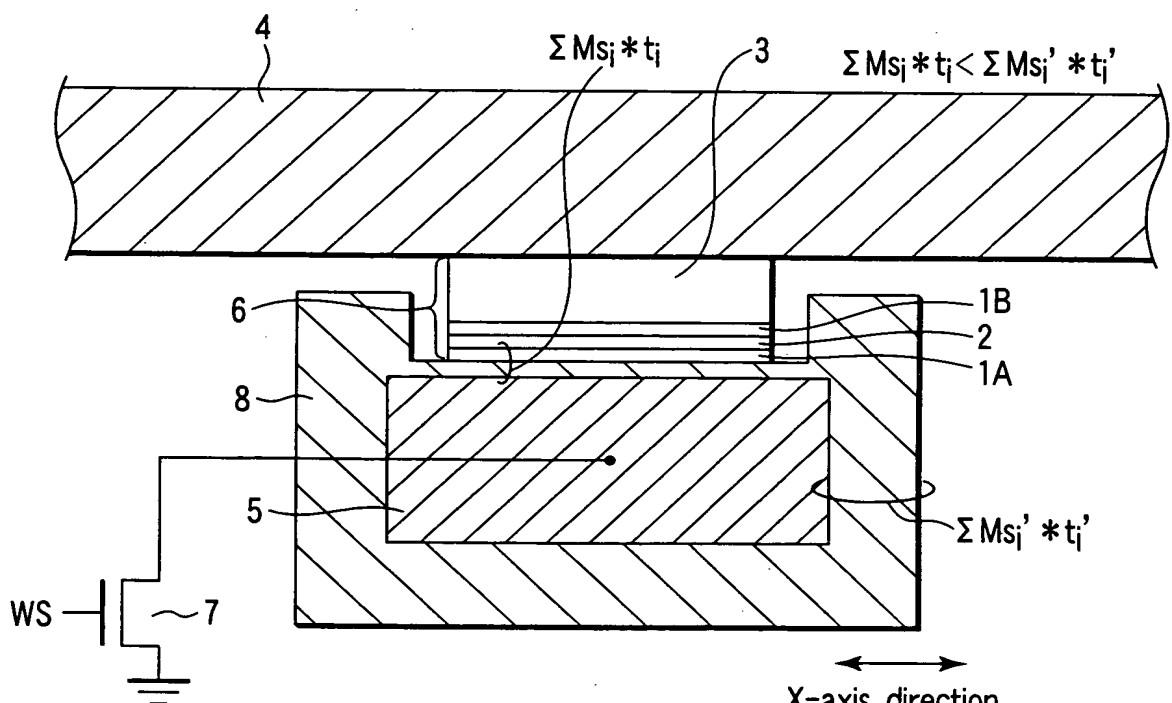


FIG. 3  
PRIOR ART





**FIG. 5 PRIOR ART**



**FIG. 6**

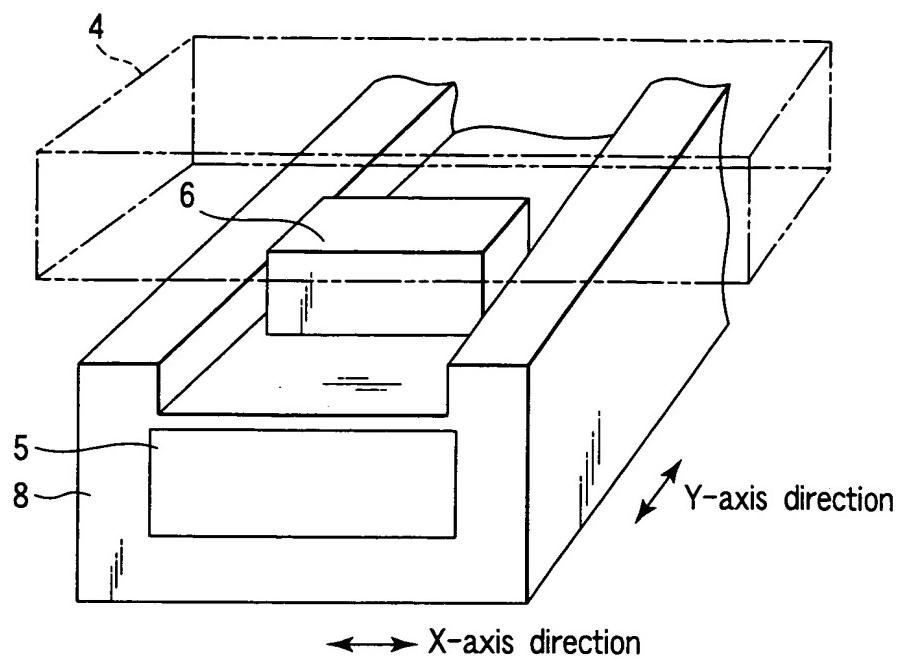


FIG. 7

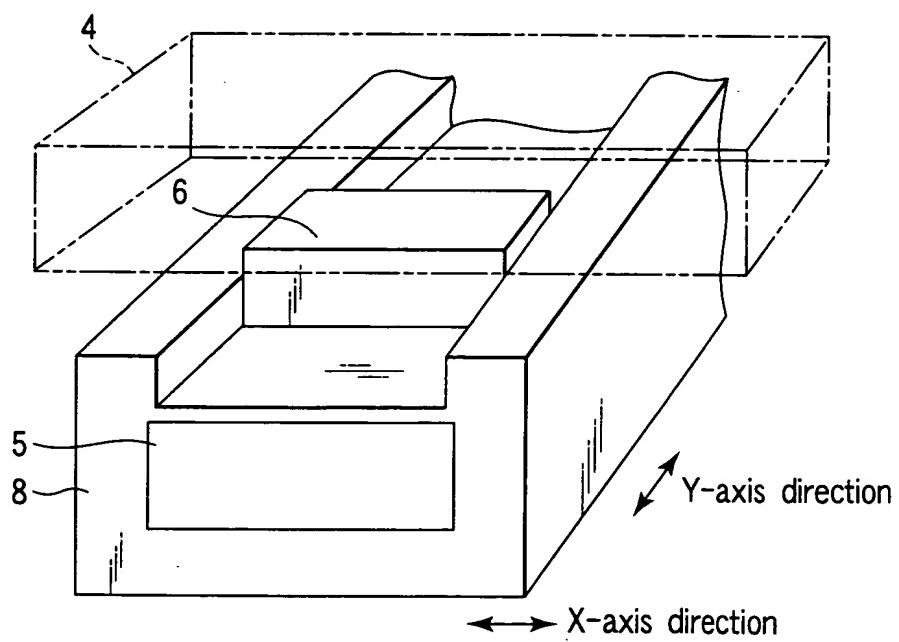


FIG. 8

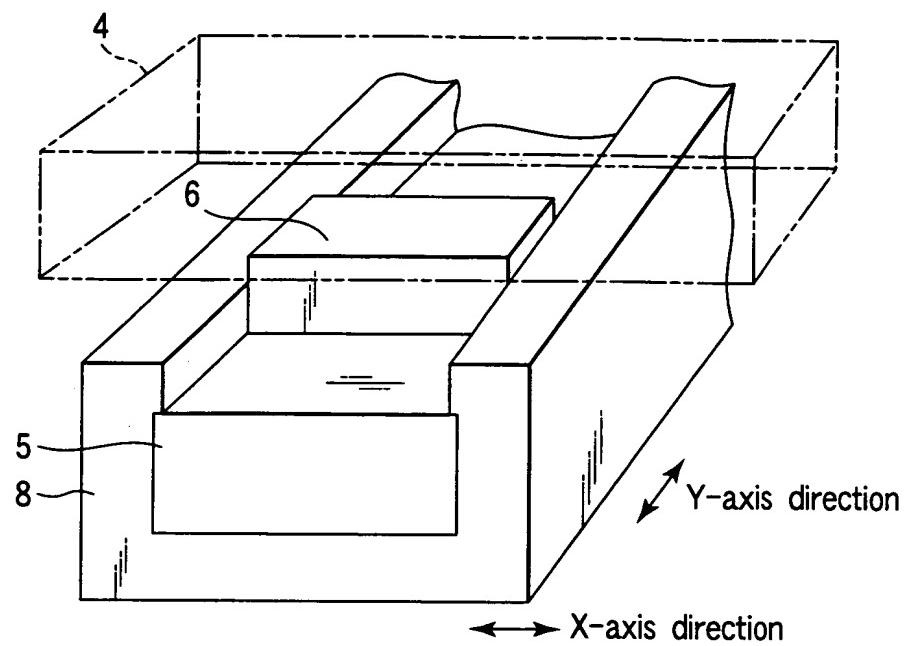


FIG. 9

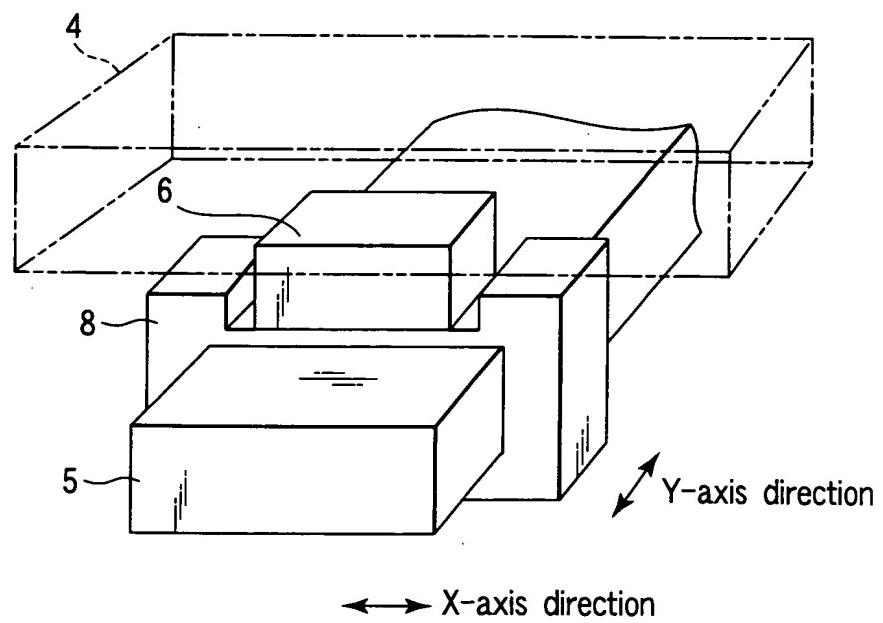


FIG. 10

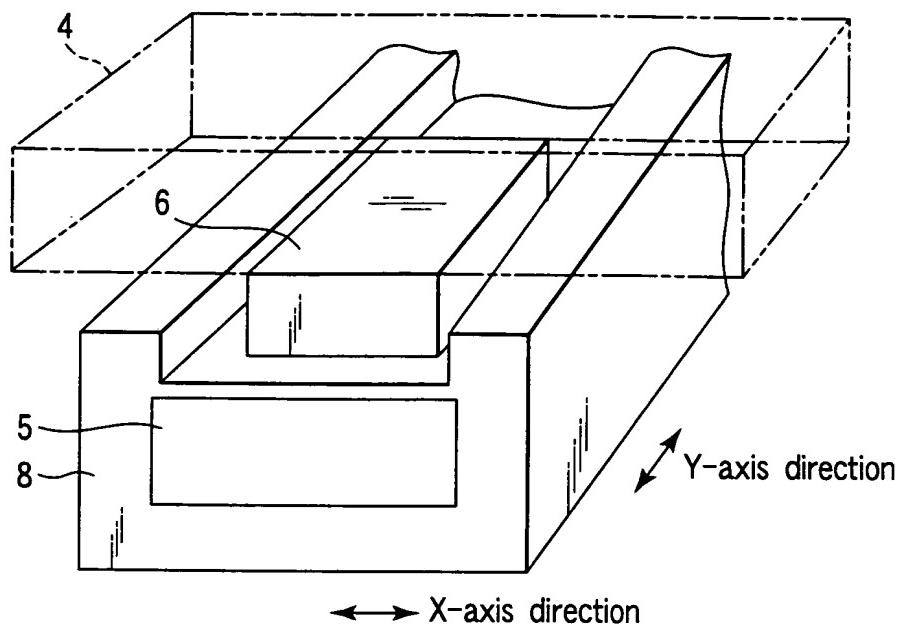


FIG. 11

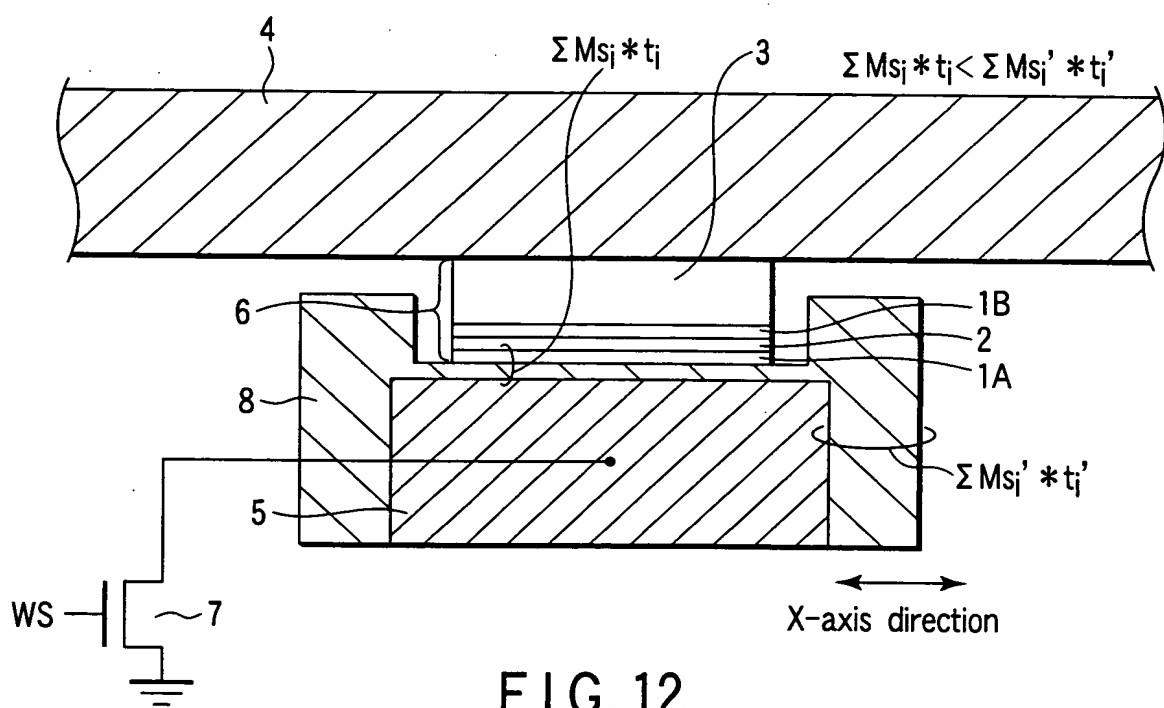


FIG. 12

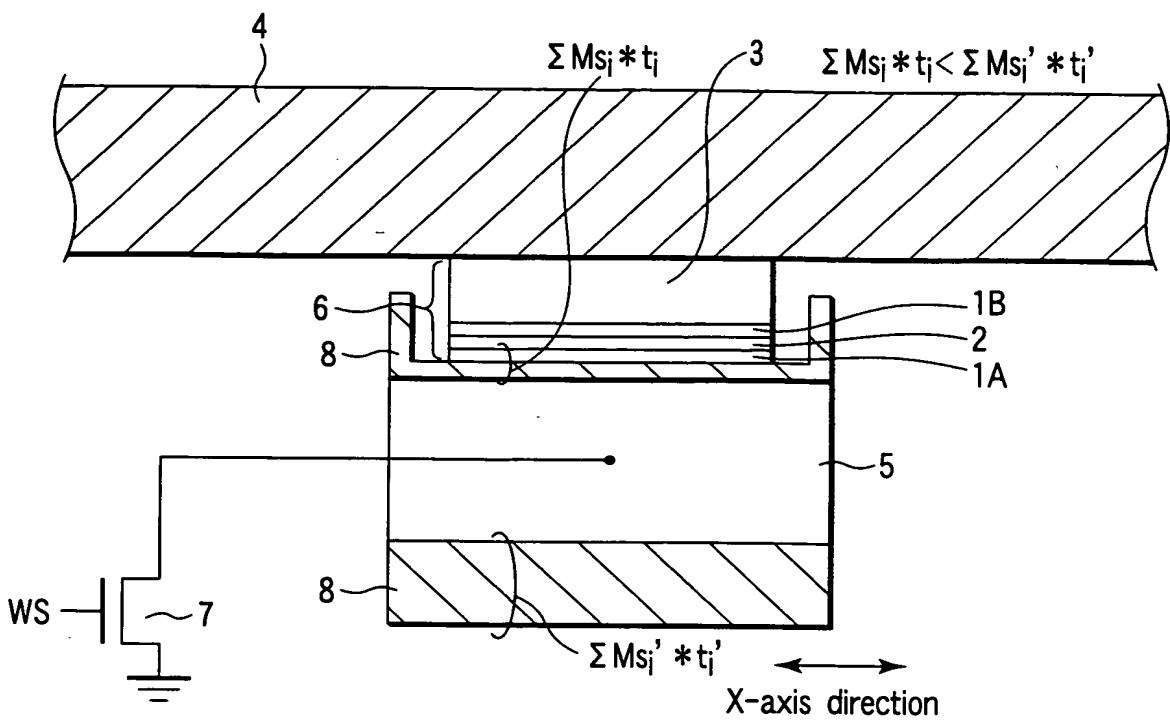


FIG. 13

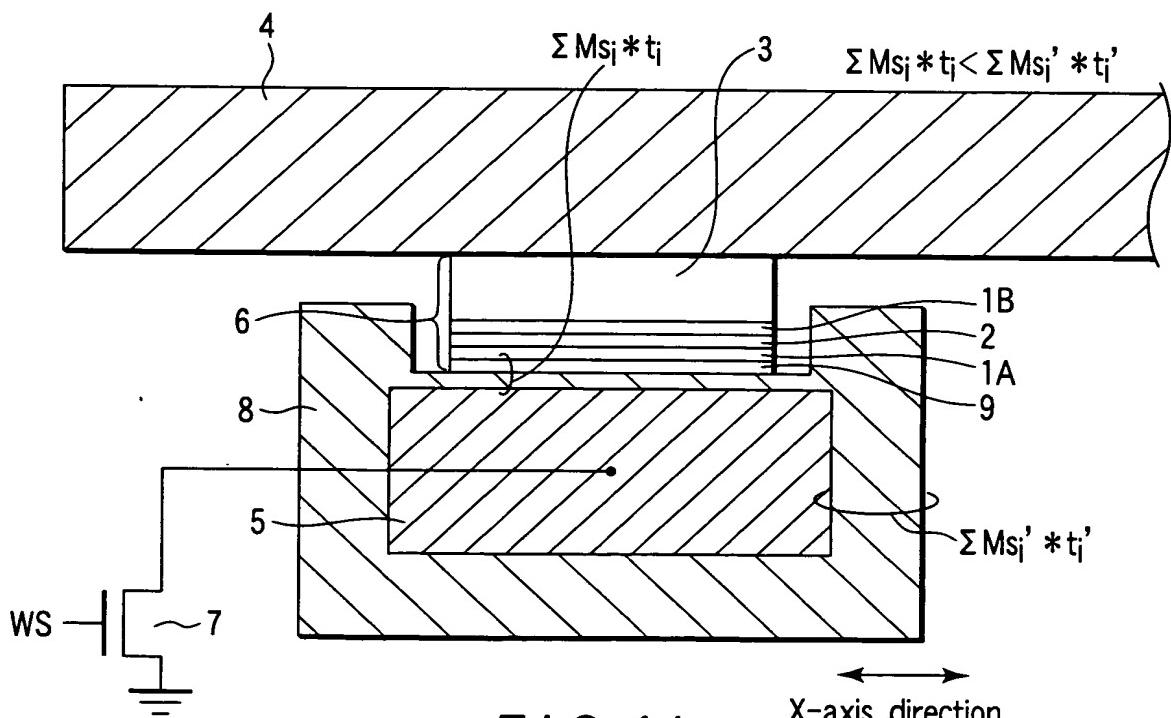


FIG. 14

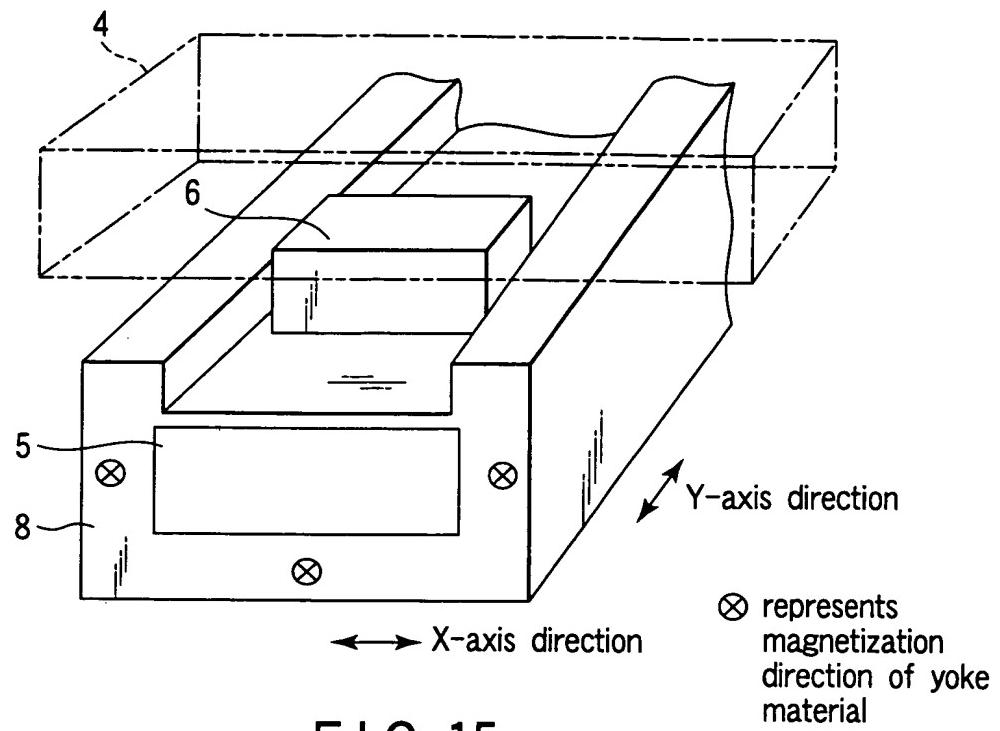


FIG. 15

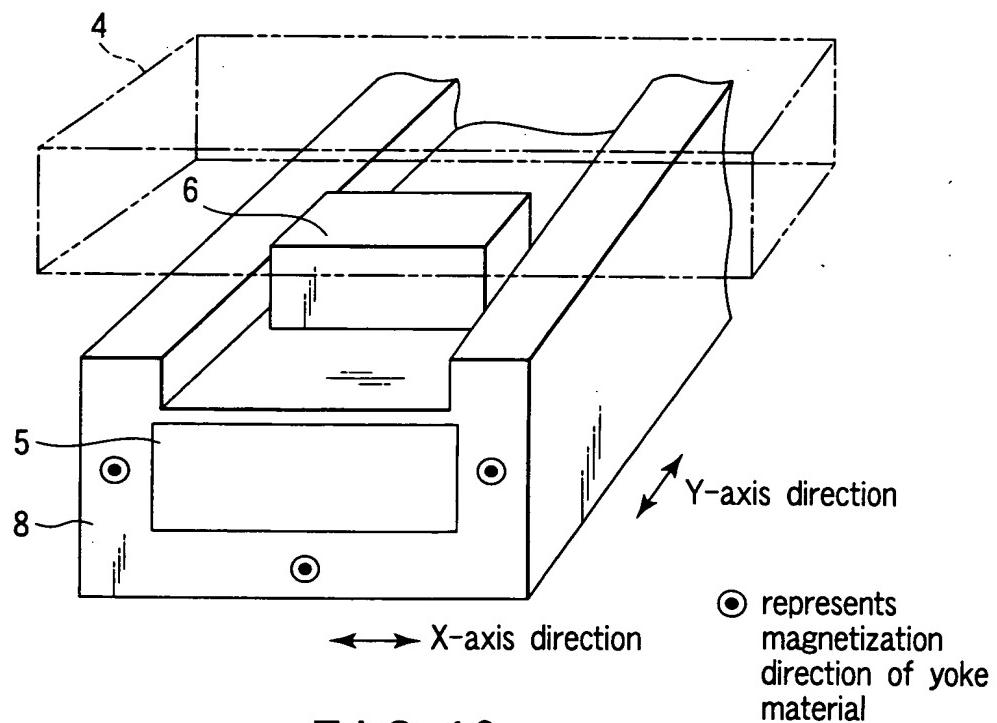


FIG. 16

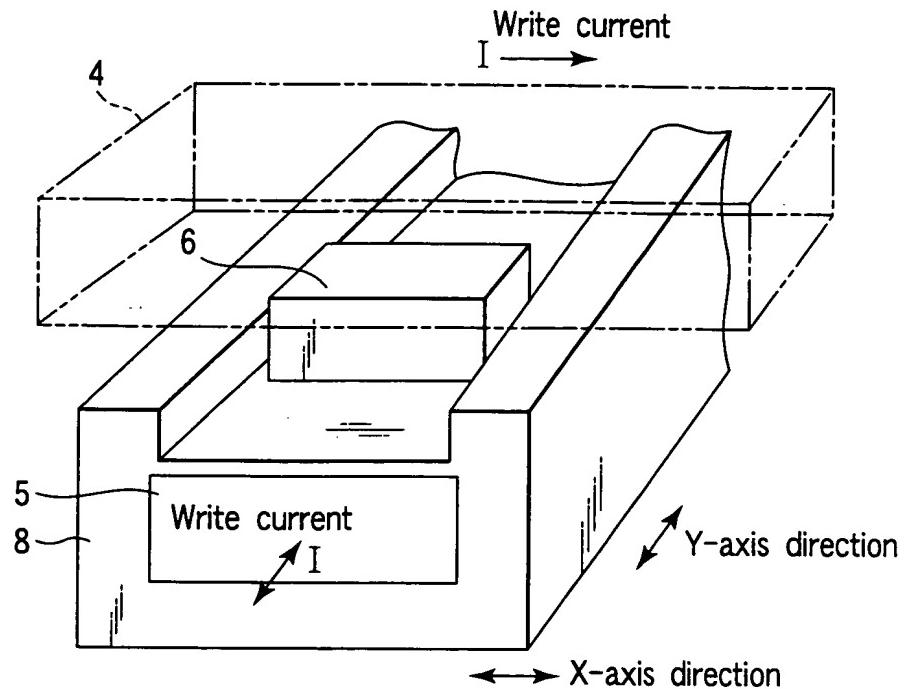


FIG. 17

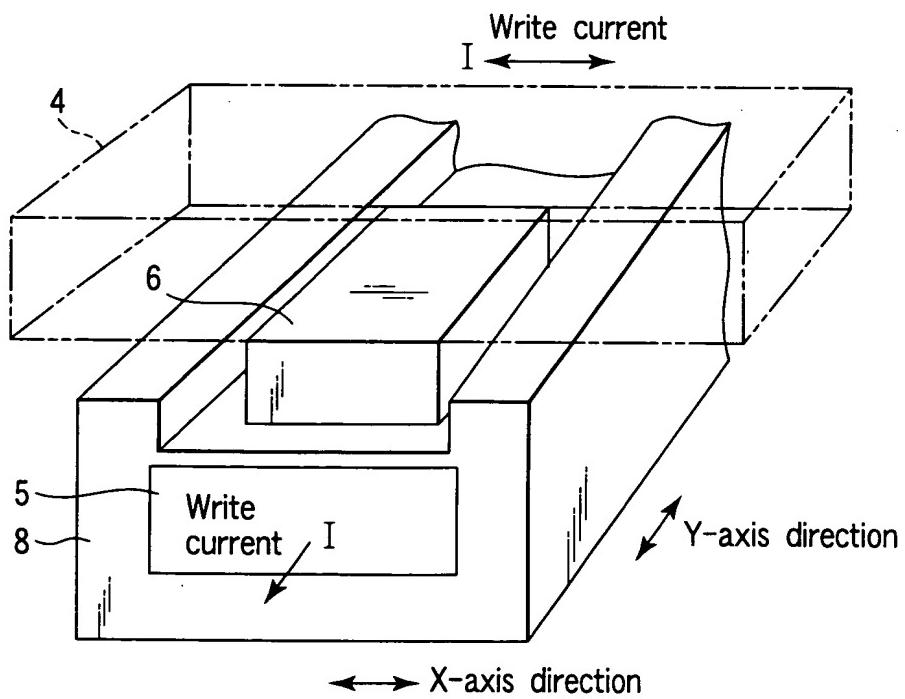


FIG. 18

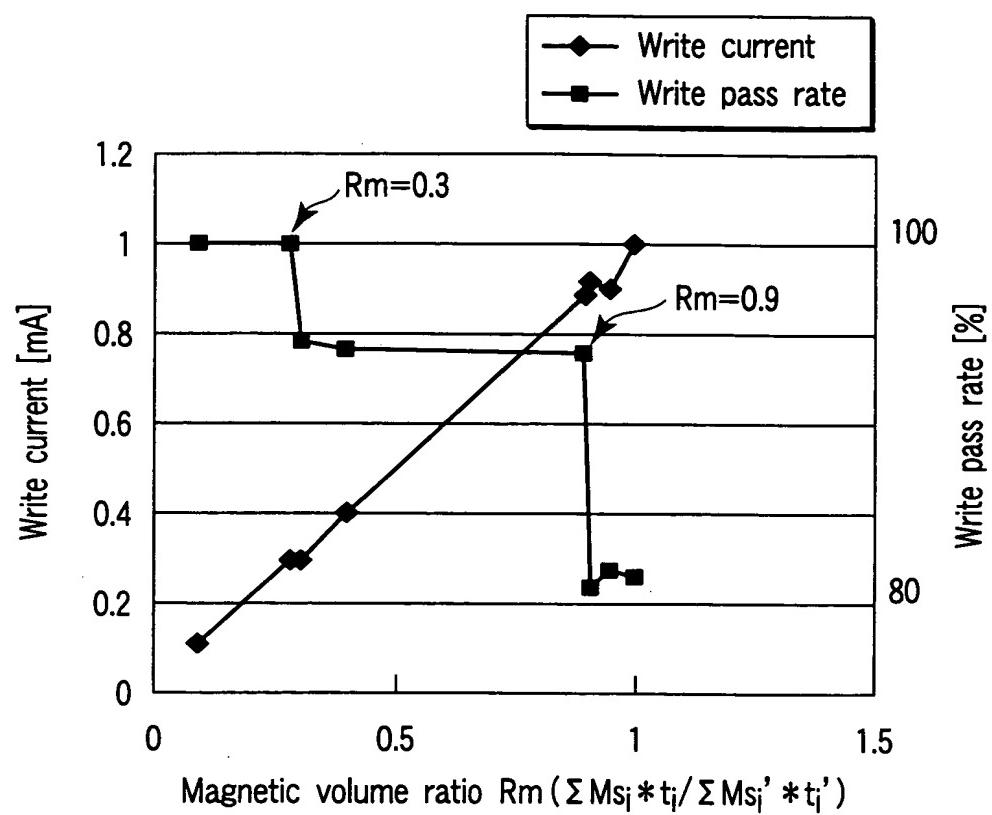


FIG. 19